Combating BLUE MOLD *of Tobacco*

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COMBATING BLUE MOLD OF TOBACCO

P. J. Anderson[1]

Blue mold, or downy mildew, first invaded Connecticut in 1937 and has caused some damage in tobacco seed beds every year since that date. It is essentially a disease of the seed beds but in a few favorable years has spread to the shade fields causing some small losses. Field attacks have usually been of short duration and are quickly stopped by hot dry weather. The two binder types of tobacco have not been damaged in the field although scattered lesions on the leaves may be occasionally observed.

During the 1951 season, however, blue mold spread disastrously in the shade fields during the last week of June and the first three weeks of July causing an estimated loss of more than two million dollars to the shade growers. Attempts to control the disease in the field by spraying or dusting were of little avail, either because applications were started too late or because insufficient quantities of fungicide were applied.

In the seed beds, blue mold can be effectively controlled by spraying with ferbam or zineb, (p. 9) and this practice is commonly followed with good success by growers. Very few growers have ever sprayed the fields, however, because, previous to 1951, field occurrence was so infrequent and damage so unimportant that the cost of spray or dust applications did not seem to be warranted.

After the disastrous season of 1951, however, many growers feel that a regular preventive program must be practiced in the field as a matter of insurance against such losses as those of last season. Unfortunately, no experiments on field control of blue mold have been conducted here or elsewhere to serve as a guide for recommending a spray program.

A project of renewed research and experimentation has been undertaken for 1952 which we hope will give us information on which to base a practical field program. Until we have more experimental evidence for the field program, the most obvious course is to assume that the same chemicals that have given good control of mildew in the beds will accomplish the same on the larger plants in the field. Naturally this will require different apparatus and other changes in procedure which will be mentioned below.

The prime purpose of this circular is to outline a possible preventive program for shade fields. This is based on our research to date. Introductory to that, however, there is presented: (1) a short description of the symptoms of blue mold both in the field and in the seed bed to enable the grower to be sure he recognizes the disease in all its stages, (2) a condensed discussion of the life cycle of the causal parasite to help him

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anticipate the stages of the disease, and (3) an enumeration of the steps of the seed bed spray program, because field control starts with keeping the beds free of disease.[1]

SYMPTOMS

The one sure diagnostic symptom of blue mold is the soft downy felt of mildew covering the lower surface of affected leaves (Figure 1). In a young stage this growth of mildew frequently is of a violet tint, which gives the popular name "blue mold" to this disease. In still younger stages the mold is white and, as the disease progresses, the mold becomes gray or brown. The first indication of mildew in a bed of green plants is the presence of faded yellow leaves, usually in patches. These yellow leaves

Figure 1. Plant infected with blue mold (right) and healthy plant (left). Note tufts of the mildew on lower side of distorted leaves.

are not flat, as they would normally be, but are humped up or irregularly puckered. Many are twisted (Figure 1) or erect so that the lower surface faces upward.

As the infected leaves die, their color depends on the weather. In wet weather they are dark green to black, become water soaked and rot away. In dry weather the diseased leaves become brown, dry and brittle. A badly diseased young bed (Figure 2) looks as if it had been thoroughly burned

[1] The reader who is interested in more detailed information about the disease itself is referred to Station Bulletin 405, "Downy Mildew of Tobacco".

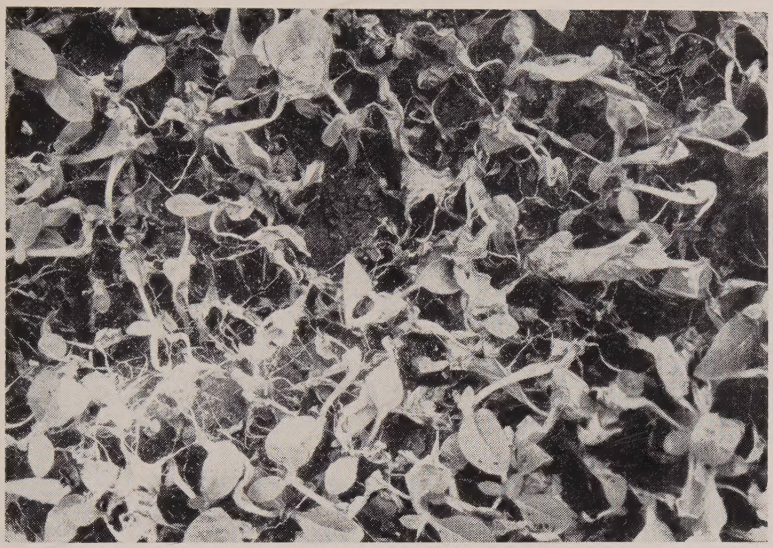

Figure 2. Blue mold in a bed of young plants. Dried leaves reduced to twisted strings on surface of soil.

Figure 3. Blue mold on mature shade tobacco leaf in field. Dead tissue has already broken out of many of the spots.

by pouring scalding water or a toxic chemical over it. Most of the leaves are dead, dry and shrivelled to mere strings, flattened out on the surface of the ground. Most small plants die since the disease runs down from the leaves and causes the stalks to rot. It may also make them more susceptible to other bed rots. The beds are often completely ruined in this stage. However, if the disease first appears after the plants in the beds are several inches high, the mold is more likely to attack only the leaves, and the stalk still lives. Such plants recover and may be set in the field but they do not survive transplanting as well as healthy plants.

Symptoms in the Field

In the field the disease does not usually kill entire leaves but it appears as spots of a half-inch to more than an inch in diameter, one to a dozen on a leaf (Figure 3). These dead areas

Figure 4. Shade leaf from field showing type of lesions produced when hot weather suddenly stops further spread.

are irregular in shape and size and sometimes are so large or numerous that the entire leaf dies. Seldom is a field uniformly affected; the trouble is more likely to be in patches while other parts of the field will be relatively free. In the first stages one sees only a faint, indefinite yellow blotch on the upper side of the leaf. This blotch rapidly becomes more definite and more yellow, and as the leaf tissue dies, it turns to a light brown. The majority of the spots show no fungus on the lower surface at this time, but if the weather is damp, one may find the mold, especially on leaves close to the ground. On examining the young spots closely, one notices numerous little brownish or blanched or sunken specks visible on both surfaces. Sometimes the entire lesion consists of a group of sunken dead brown specks and the remainder of the leaf remains green (Figure 4). Only a few well developed spots on a shade leaf are needed to make it worthless commercially. In the warehouse the spots are blanched dry tissue which cracks or falls out and the leaves cannot be used for cigars.

LIFE CYCLE OF THE CAUSAL PARASITE

Blue mold is caused by the attack of a parasitic fungus *(Peronospora tabacina)*. A short description of the life cycle of this fungus will help the grower in his understanding of the course of the disease and to a more intelligent control.

During most of its life this fungus lives inside the leaf and is not visible to the naked eye. It becomes visible only when it comes to the surface of the leaves to produce spores and may be seen as a fine felt or mold as previously mentioned (Figure 1). This mold-like growth is composed of innumerable branched tree-like sporophores which bear the summer spores on the tips of the branches. These lemon-shaped spores are so tiny that a thousand of them placed end to end would measure one inch. They are also very light in weight so that they are dislodged with the least air movement and float off into the air like the smallest dust particles. They may not come to earth again until they are many miles from the bed in which they developed. Unless they happen to fall on to a tobacco leaf, they die within a few hours or days. If, however, they fall on a tobacco plant and there is moisture on the leaf, they germinate in two to four hours by pushing out a slender, rapidly elongating tube (comparable to a tap root of a seed). This

germ tube may bore directly through the epidermis or it may penetrate to the interior tissues of the leaf through a breathing pore (stomate). Once inside the leaf, it rapidly ramifies between the leaf cells and soon permeates a large area of the leaf, sucking its nourishment from the cells by means of microscopic sucking organs (haustoria). Moreover, it secretes a poison which causes the invaded portion of the leaf to fade and finally die. If the atmosphere is quite moist, the fungus will, before it dies, push to the undersurface of the leaf and produce a new crop of spores, thus completing the cycle. This complete life cycle requires an average of about seven days (the incubation period). If, however, the atmosphere is too dry or the temperature too high, the appearance of the spores will be delayed or the fungus will finaly die and the leaf tissue turn brown without any mold on it. It is for this reason that spores are not often seen on the lesions in the field. The weekly life cycle may be repeated many times if the weather conditions are favorable.

Another type of spore, the winter spore (oospore), is developed inside the leaf in some sections of the country but it is not definitely known whether it occurs in Connecticut. It is thick walled, resistant to unfavorable weather and is liberated only when the leaf decays. It lives all winter and is believed to start the spring infection.

HOW THE WEATHER AFFECTS MILDEW

Moisture, temperature and light are the three weather factors that determine the severity and course of blue mold.

Moisture. As indicated above, free drops of water standing on the leaves for a minimum period of four to six hours are needed to give the spores a chance to germinate and the germ tube to enter the leaf. The longer the wet spell lasts, the greater the number of infections and severity of the disease. Thus, outbreaks of mildew follow about a week after rainy periods (length of the incubation period). Too, the emergence of the sporophores on the lower surface of leaves can take place only when the atmosphere is almost saturated with moisture. If such a condition does not prevail at the end of the incubation period, emergence is delayed until the atmosphere becomes more moist. The air is most often saturated during the night and, for this reason, new spore crops are most frequently seen in the morning. The moist atmospheric condition which is commonly maintained in seed beds is ideal for propagation of the fungus. In the field, however, the air is usually not saturated enough of the time and at the proper times to maintain suitable conditions for the spread of the fungus. An exception, however, was in the season of 1951 when there were frequent extended rainy spells (accompanied by low temperatures) so spaced as to furnish ideal conditions for field spread from the middle of June to the middle of July.

Temperature. The parasite thrives best at low temperatures, 50 to 70° F. being the most favorable. Spores are developed at 42 to 63° with most abundant production at 56° and they cease to appear above 68°. Such temperatures commonly prevail in the seed beds at night. At temperatures

above 80° the fungus becomes inactive and finally dies. Thus, in 1951, when the temperatures ranged from 80 to 90° for several days, the disease stopped.

Light. Low light intensity favors growth of the fungus and the disease is usually first found in shaded portions of the bed. This lower light intensity, along with higher humidity, and a more succulent growth accounts for the greater danger of blue mold in the shade tents than in the open fields. If spores are exposed to direct sunlight for only a few hours, they are killed.

Succulence. A fast growing succulent plant is much more subject to blue mold than a hardened slow growing one. Growers noted in 1951 that those fields where the plants were in the rapidly growing, "shooting" stage when the outbreak occurred were most severely damaged. Forced plants in the seed beds are more susceptible than those which are allowed to develop more normally.

ORIGIN OF THE 1951 OUTBREAK

What was the origin of the 1951 outbreak? Where did the supply of spores come from? Four possible sources could be enumerated.

1. From winter spores which survived in the field soil from the previous year. This seems very unlikely because there was little, if any, disease in the fields the previous year. Oospores are not definitely known to occur in Connecticut and at most they must be rare.

2. From summer spores which were developed in the late fall of 1950 on volunteer plants and managed to survive the winter. Although we have no evidence that these spores can survive that long a period, this possibility is not fully precluded.

3. From summer spores blown into this region from farther south. However, the dilution of spore load when they have travelled that distance seems too great to account for the widespread outbreak.

4. From spores either blown from infected seed beds in the neighborhood or from infected plants that were transferred to the field from such beds. This seems to be the most logical conclusion. The writer saw a number of beds that were infested and had crops of spores in them during the first two weeks of June. We have seen many cases in previous years where adjacent fields have been infected from diseased seed beds. The plants in many beds had not yet been destroyed when the field outbreak was initiated in the middle of June last year. Some growers set plants in the field from infested beds. Thus, there was such an abundant supply of spores close at hand that it seems unnecessary to look for a more distant source of inoculum.

The origin of the first infections that occur in the seed beds in the spring is still a matter of conjecture. It has been postulated that they start from winter spores that have lived over in the soil from the previous season, but since all of our beds are sterilized each year, and since this practice should kill all spores, we must assume that they are brought back into the bed soil from some source outside the beds. The possibility that some of the summer spores (which the writer has occasionally seen on volunteer shade plants as late as October) may live through the winter and blow back into the beds has not been sufficiently investigated. The blowing of some spores from the south is the third possibility.

CONTROL IN THE SEED BED

The primary reason for keeping mildew out of the beds is to save the seedlings because past experience has shown that young beds may be badly damaged or ruined. Since infested beds are the most likely source of field damage, the second reason for keeping the beds clean is to reduce this danger to the lowest possible limit.

Good methods of controlling mildew in the beds are well known and already practiced by most growers and, therefore, need no discussion in detail. The directions given below are not new but may be useful to the grower for ready reference and emphasis.

Fungicides to be used. Two related chemicals have been found to be equally effective, ferbam and zineb. *Ferbam* (ferric dimethyl dithiocarbamate) is a black wettable powder marketed by several companies under different trade names: Fermate, Karbam-Black, Nu-Leaf, Ferradow, Niagara Carbamate, and others. *Zineb* (zinc ethylene bisdithiocarbamate) is also marketed under different names, two of which are Dithane Z-78 and Parzate. It is a white wettable powder. Each of these may also be obtained in a form diluted with inert materials and thus suitable for dusting on the plants instead of spraying. Dusts and sprays are equally effective.

Dilution. One pound of ferbam or ¾ pound of zineb should be stirred in 50 gallons of water when the plants are small. After they are half grown, the strength should be doubled to 2 pounds and 1½ pounds, respectively.

When to start. Applications should start the first week in May.

How much? Sprays are most effective if applied until every leaf shows black or white drops of the spray material. If dust is used, likewise every leaf should show a fine deposit of dust. This will require about 3 to 5 gallons of spray to 1,000 square feet of bed space, depending on the type of sprayer used (1 to 1½ ounces of actual ferbam or ¾ of that amount of zineb for the initial sprays). If one wished to equal this with, for example, a 20 per cent dust it would require 5 to 7½ ounces to 1,000 square feet to begin with and 10 to 15 ounces for later applications.

Sprayers. Any type of spray pump or duster is suitable if it gives good distribution of the fungicide. Some growers have even used sprinkling cans but some sort of a compressed air sprayer gives better distribution and is more economical with material. Small power sprayers save labor and give good distribution. There are so many different kinds of satisfactory spray pumps and dusters that the choice must be left to the individual. Where the beds are equipped with automatic watering equipment, the fungicide may be applied through the same pipes and nozzles as the water.

How often? Beds should be sprayed or dusted regularly twice a week.

Time of day. It is better to let the spray dry on the leaves before watering the plants; otherwise, much of the spray will be washed off the leaves. For this reason morning is the preferred time to spray. No application, however, should be omitted because of wet leaves. Spray regularly, regardless of weather, except during pouring rains.

When to stop spraying. Spraying or dusting should be continued as long as any plants are still growing in the beds. Late spraying is particularly important from the standpoint of field control. Most growers stop spraying as soon as they have finished setting the fields but they keep the plants alive for several weeks in the beds in case of emergency. Such unsprayed beds are ideal hot beds for propagation of blue mold and production of spores that can fill the air for miles around. The plants in these beds should be destroyed just as soon as one is reasonably sure he needs no more plants. They may be destroyed by pulling or hoeing but a better method is to drench them with formaldehyde 1-50 and leave the sash on until they are all dead and dry. This also kills all spores that are present. Methyl bromide may also be used by the same procedure used in fumigating the beds. *Other tobacco growers in the area may suffer if centers of infection are left unsprayed.*

CONTROL IN THE FIELD

As has been intimated above, the first step in preventing damage in the field is to keep blue mold out of the seed beds. An individual farmer, however, can never be sure of avoiding field damage even when his beds are free of disease. A neighbor's beds may furnish all the spores that are needed for infecting his fields. Thus, control is a community affair, a responsibility of all the growers. Although one unsprayed seed bed may infect a whole community, one must not conclude, however, that it is useless to keep it out of his own beds. We shall probably never be able to eliminate all the fungus in the Valley. However, by reducing the foci of infection, we will reduce the chances of infection and probably the extent of the damage.

Beds that are known to be infected should be destroyed by the methods mentioned above. Plants from an infected bed should not be set in the field. In addition to the danger of carrying spores to the field, the survival chance of diseased plants is quite low.

If a spray or dust program is to be undertaken in the field, it should be an extension or continuation of the same program as outlined above for beds. Ferbam or zineb should be applied every four days at about the same rate as it is applied to the beds. Applications may be started just as soon as the plants straighten up and start to grow. They should be continued through the month of June. If no blue mold has appeared by the first week in July, it would probably be safe to discontinue the program; otherwise, it should be continued up to the middle of July or until hot weather stops the spread of the disease.

Rate of application. There is no reason to believe that blue mold can be stopped in the field with less fungicide than we use in the beds. As mentioned above, it requires 2 to 3 ounces of ferbam to 1,000 square feet of bed. Figuring at the 2-ounce rate, an acre would thus require 86 ounces or at least 5 pounds when the leaves begin to cover the ground. If proper equipment is available to put the sprays directly on the rows of small plants without wastage between the rows, this quantity could be reduced. If diluted dusts are used, they should be applied at a rate to give the pounds of actual fungicide just mentioned. Thus, if one used a 35 per cent ferbam dust, it would require 15 pounds of the dust to the acre. Experiments on beds in the South indicate that zineb is effective at about three-quarters of the rate for ferbam. Thus, one should get the same control with 3¾ pounds of actual zineb as with 5 pounds of ferbam.

Residues and Diluents

Any spray deposits or discoloration on plants in the seed bed are not objectionable since these leaves are never harvested. The same is true of the early leaves in the field. However, as the plants begin to grow, they develop the leaves which are to be harvested and these leaves must not be discolored by spray deposits. Ferbam leaves a black or rusty deposit and zineb is white. True, these become less noticeable with rains and weathering before harvest and through handling, but late applications especially are not so likely to disappear. Everything should be done to avoid or reduce these chances. Excesses of sprays or of dusts should be avoided. If possible, diluents should be of the same color as the cured tobacco leaf. In this respect, sterilized tobacco dust is ideal. Other diluents of about the same color can be used. Dusts in general will leave less prominent deposits than water sprays. Fine distribution of the spray is also helpful. With proper equipment, a concentrated spray can be so finely atomized that the tiny drops are hardly noticeable.

Sprayers and Dusters

Equipment which gives the best distribution is to be preferred (see cover picture). It should divide the material into as small particles as possible.

Mist blowers and aerial equipment are ideal for this and very high concentrations of the spray or dust can be used without plant injury and with a minimum of residue.

Mixing the blue mold dust with insecticides. If DDT is used for the control of insects during the period when the blue mold spray is used, it may be added to every second or third application at a rate to furnish 1 pound of actual DDT to an acre. Thus, if the grower is applying 12 to 15 pounds of a zineb dust to the acre, it should contain 25 per cent zineb and 6 to 7 per cent of DDT.